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Executive Summary

The Government of Netherlands (through the Asian Development Bank) and the Government of India has jointly launched a project entitled 'Energy Efficiency Support Project (ESP)' to look into various aspects of energy and environmental issues pertaining to the Indian industry. The project comprises of two distinct phases. Phase-I of the project deals with identification of industry sectors where there is a substantial scope for energy saving and pollution reduction through energy efficiency investments. Phase-II of the project primarily covers various initiatives like undertaking energy and environmental audits, feasibility studies, training programmes and promotional campaigns for industry sectors identified under the phase-I of the study. One of the sectors covered for detailed analysis by TERI under phase-I is the textile sector.

The Indian textile industry accounts for 20% of the total world production and contributes to 25-30% of the total value of exports from India. Due to new economic policy of the Government, there has been a tremendous growth in textile industry in the recent past. Government has announced several liberalised measures and benefits for exports and imports. As a result, there is a good competition among Indian mills to improve quality and export their products in large quantity. This report presents a macro assessment of the cotton textile industry. The reason for selecting this particular segment stems from the fact that industry at present is predominantly cotton based which accounts for nearly 60% of the total fabric production.

Total energy consumption in this sector was about 30.56 million Gcals in 1993-94. The energy consumption in the form of coal, fuel oil and electricity were 18 million Gcals, 5.25 million Gcals, 7.31 million Gcals respectively. The cost of energy as a percentage of production cost in this sector has increased significantly during the past decade. Fuel and power accounts for 12-15% of the total cost of production at present. The trend is expected to worsen in future because of increasing fuel prices.

Overall energy saving potential in this sector is estimated to be 23%. The major energy saving measures applicable for the textile industry are listed below.

- Automatic soft flow machine for scouring, bleaching, dyeing and washing with microprocessor control system;
- Automatic drying machine for fabric;
- Energy efficient radio frequency dryer;
- Smaller wrap diameter spindles;
- Light weight ABS material pulley in ring frame.

CHAPTER 1

Introduction

The Indian Textile industry accounts for 20% of total world production and contributes 25% to 30% to the total value of exports from India. Most of the mills are old and machinery is based on outdated technology. Until a few years ago, the industry was in financial difficulties. But now we see a change sweeping the industry. Several private sector mills are modernising and expanding. Under the new world trade agreement, textile export quota to USA and European countries have been enhanced. Even though textile exports from India are increasing rapidly, presently, they constitute a mere 2% of the world trade.

Due to new economic policy of the government, there has been tremendous growth in textile industry in the recent past. Government has announced several liberalised measures and benefits for export & import. As a result there is a good competition among Indian mills to improve quality and export of their products in large quantity. Many prominent textile groups are setting-up EOU's and also modernising their old units. While the demand for man-made fibers/yarn is fast growing, cotton still accounts for more than 70% of raw material consumed. However, the consumption of 100 percent cotton fabrics has shown a declining trend by dropping to 52% in 1990 from 72 percent in 1984 and again increasing to about 64% in 1993-94.

This report presents a macro assessment of the cotton textile industry. The reason for selecting this particular segment stems from the fact that industry is predominantly cotton based, which accounted for 60% of the 17,500 million meters of annual fabric production in 1991-92 with the per capita consumption of woven fabric around 14.5 metres, and population around 850 million. The annual plan reported the cotton based fabric production has been increasing upto 70% in 1992-93 and 80% in 1993-94. The following sections of the report deals with energy use pattern, the energy and environment performance, energy saving potential and other related issues pertaining to the cotton textile industry.

CHAPTER 2

Sector profile

2.1 Overview of Cotton Textile Industry

The textile industry can be classified into (i) textile mills comprising composite and spinning mills in the organised segment, and (ii) small powerloom and handloom units in the decentralized segment. The mill sub-sector which is the single largest industry group in the organised industrial sector in the country, accounts for just 12% of cloth production. Yarn is produced by the mills in the organised segment, but is consumed by powerloom and handloom segments as well. The ownership profile shows that of the 1062 mills were existing in 1990-91, over 70% of mills are under private ownership. All the 106 mills under co-operative management are spinning mills. The Central and State sectors have 20% mills under their control, most of which have taken over from private managements, due to sickness. The total number of mills increased to 1117 and 1142 in 1991-92 and 1992-93 respectively. While the installed capacity is an indicator of the trend of growth of the industry, the real size of production is determined by the utilization efficiency of the capacity. The utilization, if only the working mills are considered, is gradually increasing in case of installed spindles but sharply declining in case of looms. In the case of spinning, both the installed capacity and utilization are showing increasing trend, whereas in case of weaving capacity both the installed capacity and capacity utilization are declining.

2.2 Production details

The powerloom and handloom sub-sectors have increased their respective shares marginally to 71.3% and 21.1% at the expense of the mill sub-sector whose share has declined to 7.6%. Production of yarn is almost entirely in the organised segment. It has also shown a steadily increasing trend over the years as can be seen from **table 2.01**. During April 1993 - November 1994, the yarn production was higher by 10.6% as compared to the corresponding period of April-November 1992-93. The output from the handloom segment has shown a small but steady increase. The output of cloth from the mill segment, which accounted for about 45% of total cloth production in 1975/76, has declined to just about 12% in 1991/92. Almost 88% of cloth production comes from decentralized segment, about three-fourth from powerloom and one-fourth from handlooms.

Table 2.01. Production of Yarn (million kgs.)

Year	Cotton	Blended & 100% Non Cotton	Total
1987	1348 (85)	231 (15)	1579 (100)
1988	1297 (83 5)	255 (16.5)	1552 (100)
1989	1337 (83.5)	265 (16.5)	1602 (100)
1990	1447 (82)	315 (18)	1762 (100)
1991	1472 (81.6)	331 (18.4)	1803 (100)

Source: 1. Handbook of Statistics ICMF - 24th Edition
2. Economic Times Review - Textile and Textile Machinery - July 1992
3. Figures in brackets indicate percentage to total.

The composition of the textile industry is undergoing a structural change. From 291 composite mills in 1980 the number has come down to 268 in 1993. There is a rather slow growth that too in the value added speciality fabrics like upholstery, terry-towels etc, and the like. Spinning mills, on the other hand, have increased from 370 in 1980 to 896 in october, 1993 and 874 as on 31.03.1993, an increase of 136%. The spinning capacity increased from 28.09 million spindles in 1992-93 to 28.40 million spindles in 1993-94 and 29.91 million spindles in 1994-95, while weaving capacity of the organised mill sub-sector decreased from 1.58 lakh looms to 1.54 lakh shuttle looms during the same period. The corresponding years contribution of shuttleless looms are 2.6%, 3.0% and 3.5% respectively. The capacity utilization in spinning has increased from 69% in 1985-86 to 78% in 1992-93 while it has decreased in the case of weaving from 62% to 51% during the same period. The study team has observed that the spinning group of mills are in the process of setting-up EOUs and expansion projects. There is a considerable growth in the number of processing units. The time series growth in the spinning capacity and the production of cotton yarn according to count are shown in **tables 2.02** through **2.04.**

Table 2.02. Growth in spinning capacity

S.No	Item	Unit	1987	1988	1989	1990	1991
1.	Spindles Installed	Million Nos					
	Spinning Mills		13 74	14 47	14 86	15 05	15 25
	Composite Mills		12 33	11.94	11 62	11 53	11 53
	Total		26 07	26 41	26 48	26 59	26.78
2	Rotors Installed	('000 Nos)	19 3	40.0	47 7	63 0	75 0

Figures in brackets show % of total spindles worked/spindles installed
Source Handbook of Statistics - ICMF, 24th edition

Table 2.03. Growth in spinning capacity

Year	Spindles (Million no)	Rotors ('000 no)	Looms ('000 no)
1990 - 91	26.67	67	178
1991 - 92	27.82	113	169
1992 - 93	28 09	127	158

Source Compendium of Textile Statistics 1993, Ministry of Textiles

Table 2.04. Production of cotton yarn according to count (In million kgs.)

	Count							
	Coarse		Medium		Fine			
Year	1-10^s	11-20^s	21-30^s	31-40^s	41-60^s	61-80^s	Above 80^s	Total
1988	117	315	216	392	153	65	39	1297
	(9 0)	(24 3)	(16 7)	(30 2)	(11 8)	(5.0)	(3 0)	(100 0)
1989	120	325	223	404	158	67	40	1337
	(9.0)	(24.3)	(16 7)	(30 2)	(11 8)	(5.0)	(3.0)	(100.0)
1990	130	352	242	437	171	72	43	1447
	(9.0)	(24.3)	(16 7)	(30 2)	(11 8)	(5.0)	(3.0)	(100 0)
1991	132	358	246	444	174	74	44	1472
	(9 0)	(24 3)	(16 7)	(30.2)	(11 8)	(5.0)	(3.0)	(100.0)

Source ICMF Statistics 1992
Note Figures in brackets indicate percentage to total

Growth in the number of looms in weaving sub-sector in composite mills and decentralised segment is shown in **table 2.05** and the production of fabrics from different weaving sub-sectors is shown in **table 2.06**.

Table 2.05. Growth of weaving sub-sector ('000 looms)

Type of sub-sector	1981	1985	1990	1991
Composite mills	208	210	181	178
Decentralised powerloom mills	499	636	900	1200

Source: Technology evaluation and norms study in Textile Weaving Sector, DSIR (1993)

Table 2.06. Production of fabrics (In million metres)

Sub-sector	1987-88	1988-89	1989-90	1990-91
Mills	3027	2808	2649	2590
	(19.2)	(17.6)	(16.2)	(14.5)
Powerloom	7633	8062	8376	9469
	(48.4)	(50.5)	(51.2)	(53.1)
Handloom	3788	3746	3933	4237
	(24.0)	(23.5)	(24 0)	(23.8)
Hosiery	1337	1334	1400	1522
	(8.4)	(8.4)	(8.6)	(8.6)
Total	15785	15950	16358	17818
	(100)	(100)	(100)	(100)

Source: Technology evaluation and norms study in Textile Weaving Sector, DSIR (1993).

Figures in brackets give % share in the total

The fabric-wise break-up of mill sub-sector for last seven years is shown in **table 2.07.**

Table 2.07. Fibre-wise Production of Composite Units (million square metres)

Year	Cotton	Blended	100% Non-Cotton	Total
1987-88	2346	827	5	3178
1988-89	2122	821	5	2948
1989-90	2087	690	4	2781
1990-91	1977	739	4	2720
1991-92	1809	695	4	2508
1992-93*	1407	532	61	2000
1993-94*	1356	575	59	1990

* Handbook of Statistics, 1993-94 and 1994-95, Indian Cotton Mills Federation

Source Technology evaluation and norms study in Textile Weaving Sector, DSIR (1993)

The average growth rate in the industry during the Seventh Five Year Plan was around 1.8% The projected production and capacity increase in the final year of the Eight Five Year Plan i e., in the year 1996-97 is expected to be around 3500 million meter in the organised segment and 21,200 million meter in the unorganised segment. The other studies as per the Sectoral Energy Demand in India, GOI gives the demand projections based on a GDP growth rate of 6% of the economy during the period 1990-2010. Expected cumulative growth rate of the sub-sectors are worked out and summarised in **table 2.08**

Table 2.08. Expected cumulative growth of sub-sectors

Year	Spindles (million nos)	Rotors ('000 nos)	Looms ('000 nos.)
1996-97	30 24	331	126
1999-2000	32.20	864	107

Spindles and rotors in spinning sub-sector and weaving sub-sector are cumulatively increasing by 2.117% and 37 67%, while looms are cumulatively decreasing by 5.545%.

2.3 Export details

Indian textile and clothing exports are the single biggest commodity exported from the country, accounting for about 30% of all exports from India. Almost 70% of the cotton woven fabric exported from India are in the grey form. This clearly indicates the incapability of Indian process houses to supply quality goods to international market. Most of the process houses in India still have the batch processes and hence long lengths of consistent finish quality are difficult to achieve. Repeat production of identical shades and prints is difficult to attain with presently employed batch processes and inefficient process monitoring facilities. Most of the Indian process houses are not equipped to meet demand of international market to supply quickly the required quality of processed fabric. The growth in the export of cotton yarn, textile fabrics and mill made piece goods are shown in **table 2.09** through **2.11** for the period 1987/88 to 1990/91.

Table 2.09. Export of cotton yarn (Qty: Million kgs; Value: Rs million)

Year	Quantity Exported	Total Production	Value Export
1987	86 09	1348	3279.10
1988	43.49	1297	2366.50
1989	53.27	1337	3137.86
1990	83.30	1447	4757.99
1991	121.18	1472	8540.03 (Provisional)

Source : ICMF Statistics 1992

The increase in the production of cotton yarn is however higher at about 3.5% per year during the past 10 years. The average count spun increased from about 25^s in 1961 to about 33.26^s in 1991. The count had been roughly increasing in steps of 0.3 to 0.4 every year and the average count is expected to be around 34.5 in 1995 and 36 in 2000 A.D. On the consumption front, cotton constituted only about 75.8% of the total fibre intake in 1987. Taking into account the present trend, the share of cotton is expected to come down to 65% of total fibre consumption in 2000 A.D. Cotton yarn production increased at a

compound growth rate of 2.8% during the period 1985 to 1990. At the present growth rate, the projected production in 2000 A.D. will be around 1900 million kgs.

Present trend shows brighter prospects for Indian weaving industry. During 1991-92 more than 17500 million meters of fabric were produced from all sectors. Currently per capita consumption of woven fabric is around 14.5 meters. At 1.5% growth in the year 1991 and onwards, would guarantee 15 meter per capita consumption of fabric in the 1995 and 17 meter per capita consumption in 2000 A.D. Conservative estimates of population (at growth rate 1.92%) arrives at presence of 910 million people in 1995 and 1000 million people in 2000 A.D. Above estimates of 1.2% compound growth in population (at the 1.5% assumed cumulative growth rate in per capita consumption of fabric) leads to requirement of fabric would be around 14000 million meters and 17000 million meters in 1995 and 2000 A.D. respectively. In addition export requirement would be to the tune of 1500 million meters and 2000 million meters in the years 1995 and 2000 respectively.

Table 2.10. Exports of Cotton Textile Fabrics

Particulars	Unit*	1987-88	1988-89	1989-90	1990-91
Mill made cotton cloth	Quantity	433 63	371.24	418.87	483 83
	Value	366 30	371 0	462.74	616.65
Powerloom cotton cloth	Quantity	314 48	381.28	421.58	490.15
	Value	197 43	265.51	365.49	457.18
Handloom cotton cloth	Quantity	73.96	79.56	68.19	63.69
	Value	100 63	114 89	112.16	122.67
Total	Quantity	822.07	832.08	908.64	1037 67
	Value	664 36	751.40	940 39	1196 5
% Growth over previous year	Quantity	58.0	1.20	9 20	14.2
	Value	44 5	13.10	25 20	27 20

* Quantity in million square meters
Value in Rs Crore

Source: Technology evaluation and norms study in Textile Weaving Sector, DSIR (1993)

Table 2.11. Exports of mill-made cotton piece goods (In million sq. meters)

	1987	1988	1989	1990	1991
Grey	307.93	260.89	277 16	326 30	327 31
Finished	118 20	127 82	125 92	139 82	110 91
Total	426.13	388 71	403 08	466 12	438 22

Source ICMF hand book - 1991

During 1989-90 India exported 419 million square metres of mill made cotton cloth, 70 million square metres of handloom cotton cloth and 422 million square metres of powerloom cotton cloth. With current export boom and new export oriented ventures it would be conservative to expect export of 2000 million metres of cloth in 2000 A.D.

2.4 Overall performance

The performance of various sub-sectors with the industry are discussed in the following sections.

2.4.1 Spinning sub-sector

The overall performance of the spinning sub-sector compared against certain important parameters is depicted in **table 2.12.**

Table 2.12. Overall performance of the spinning sub-sector

Sl. No	Parameter	Unit of Measurement	Average Value	Range
1	Ring spindle utilisation	%	90	60-100
2	Output per spindle	kg/day	0 22	0 09-0 63
3	No. of spindles allocated per man	Number	68	37-106
4	Yarn production per man	kg/man shift	15	7-41
5	Electrical Energy Consumption	kWh/Spindle/day	0 93	0.46-1 60

Source: Technology evaluation and norms study in Textile Spinning Sector, DSIR (1994)

From table 2.12 it can be seen that utilisation of ring frame spindles is high (at 90%). However, there is significant scope of improvement in productivity level (as indicated by the average value of spindles/man, output per spindle and yarn production per man shift). The industry's energy consumption is on the higher side with an average of 0.93 kWh/Spindle/day. Spindle speed at an average of 12,800 is considered to be quite low.

2 4.1 1 Spinning Mills

Majority of the textile units in India employ outmoded machineries. On the other hand, there has been significant advancement in the development of textile machinery the world over. Starting from Blowroom - Carding - Drawframe - Speedframe - Ringframe, post

spinning operations like TFO's, Autoconers etc. Some of the units surveyed belonged to progtessive groups like Vardhman group of mills, Oswal group of mills and Thapar group.

EOU's have installed modern equipments with automatic systems as follows:

Blow Room	-	Rieter, Trumech
Carding	-	Rieter, Trumech
Draw Frames	-	Rieter, LMW, Cross roll
Speed Frames	-	Rieter, LMW, Cross roll
Ring Frames	-	Rieter, LMW, Cross roll
TFO's	-	Ster Volkman, Vijay Luxmi, Prerna
Auto Coners	-	Sheleforst, Padmatex
Automatic humidification system with Rotary filters	-	Luva, Batliboi
Modern Testing facilities	-	HVI, UT-3, Classimate, Instron

2.4.1.2 Semi-Modern Mills

These mills are termed as semi-modern mills because they have undertaken modernisation on a piece-meal basis. Some of them have installed Autoconers, TFO's or Open-End machines or high speed Cards or a few modern Ring Frames in a piece meal basis whereas other connected process machines are old.

These mills have made comprehensive modernisation plans but due to paucity of financial resource, or other reasons could not carry out total modernisation of their respective mills. They may be in a position to carry out modernisation provided they get adequate financial aid.

2.4.2 Weaving sub-sector

The overall performance of the weaving sub-sector against certain important parameters is shown in table 2.13.

Table 2.13. Overall performance of the weaving sub-sector

Sl No	Parameter	Average value	Range
1	Loom capacity utilization -%	67	45-100
2	Manpower employed per 1000 meters of	16	11-24
3	Electrical energy consumption-kWh/loom day	50	17-146

Source: Technology evaluation and norms study in Textile Weaving Sector, DSIR (1993)

Weaving Mills

Exclusive weaving mills in the organised segment are very few in numbers. In the northern region a few weaving mills/weaving-cum-processing mills are coming up. They are manufacturing value-added speciality fabrics like upholstery/covering materials, terry-towels, suiting/shirtings, etc Also there is a substantial growth in the knitting-cum-processing units.

Those composite mills who have old weaving machines, need to modernise them by replacing these by automatic/air-jet looms so that they can manufacture value-added fabrics. The mills, however, will require considerable financial assistance for this changeover. As such more than 80% of the country's fabric requirement is met by decentralized powerloom segment.

2.4.3 Composite Textile Mills

Still there are a good number of progressive groups who are running the composite mills quite efficiently, disproving various theories attributed to the un-viability of composite mills in today's context. The composite mills surveyed, belong to progressive groups and their performance track record is excellent both quality-wise and market demand-wise. They have continuously modernised their mills in every possible manner and as a result sustained their growth.

By better planning and effective management control they could modernise, increase the machinery utilisation, improve machinery maintenance, rationalise the workforce, implement expansion projects and as a result increase their profitability.

It is felt that the composite mills can achieve better growth provided the management undertake a pragmatic approach, right type of modernisation plan, incentive schemes and adequate financial back up

2.5 Manufacturing Technology Status

2.5.1 Spinning Mill Processes

Today there are four technologies available in cotton spinning process.

1. Ring Technology :Ring spinning is the most conventional and versatile system. The major advantage of ring spinning is its wide adaptability for spinning the entire range from yarn coarse counts of 2^s to fine count of 140^s. The major limitation of this system is that the process needs several sequences to produce yarn from the

fibre stage. In the conventional ring spinning, increasing spindle speed beyond a level was technologically difficult and economically not feasible.

2. Rotor or Open end Technology :The primary objective of open end spinning was to eliminate the spindle and ring and to form the yarn through air suction. The distinguished features of this process compared to the conventional ring spinning are following:
   - Increase in production;
   - Modified design of rotor eliminated one drawing stage, roving and winding.

   The productivity of the rotor spiting machine is about 5 times that of ring spinning machine. However, the latest generation rotor spinning machines are capable of operating at 100,000 to 120,000 rpm and producing yarn of adequate strength of upto 40^s counts.

3. Friction or Dref Technology :This system omits speed frames. The productivity of friction spinning is about 7 times higher than ring spinning. The basic limitation of friction spinning is that it can spin maximum length of 40 mm and practically can spin upto 15^s count.

4. Air jet Technology :The latest addition to the commercially available technologies is the air jet spinning system. This system omits speed frame stage. The output of this system is about 5 times higher than the ring spinning technology. This system is best for count range of 40^s to 80^s and is suitable for longer staple fibers beyond 60 mm length.

Table 2.14. Parameters of different spinning technologies

Parameter	Ring Spinning	OE Spinning	Friction Spinning	Airjet Spinning
Raw material	Cotton, viscose, polyester, Acrylic & their blends	Same as ring spinning	Same as ring spinning	Synthetic and reach blends of polyester cotton
Spg Limits	6^s-120^s	Upto 30^s but economical upto 24^s under Indian condition	6^s to 18^s	20^s-80^s but results are best from 40-80^s
Fibre preparation required	2 passage of drawframe with speed frame	1-2 drawframe passage	can be eliminated	2 passage of draw frame, combing eliminated for cotton
Production Speed (Yarn delivery speed)	-	5 times faster than ring frames	20 times faster than ring frame (delivery speed goes higher when count becomes finer)	10-12 times faster than ring frame. (delivery speed does not change with count)
Labour Content	-	Less labour required because of reduction in no of sequences and higher production speeds		
Production space for given output	-	15 to 30% less than ring	90% less than ring	40% less than ring
Yarn take-up	Bobbin	<Cross wound package . . ..>		
Energy requirement per kg of yarn produced	-	10% less than ring spun	20% less than ring spun	15% less than ring spun. (finer the yarn lower the energy consumption)
Capital Investment for same production	-	5 to 20% more than ring spun technology	-	40 times more than ring spun technology
Flexural rigidity	-	Stiffer than ring spun yarn		
Cloth & cloth proper-ties	Weaving performance is superior than ring spun Tensile and tearing strength is reduced than ring spun Handle, cover and resistance to abrasion is better. Bursting strength is comparable.			

Majority of yarn produced being of coarse to medium counts, Indian spinning industry still prefers the conventional ring technology over the other technologies. However, units with open end spinning are also increasing in numbers whenever the product mix consists of coarse counts. This is due to higher productivity of this technology. Friction spinning is yet to be introduced in India on a commercial scale.

2.5.2 Weaving Mill Processes

There is a slow shift from non-auto looms to autolooms in the composite sector. Many existing and new units are going in for these sophisticated shuttle and shuttleless weaving machines. Performance of any weaving machine depends on yarn breakage rate. Another parameter like hairiness of spun yarn and filament breaks in filament also hampers the

performance of weaving machines. In both cases frequent cleaning of weaving machine is required. More than 33% of the looms installed in composite mills are automatic looms. However, autolooms installed in decentralized segment and powerloom sub-sector are few in number. Speed of these autolooms or shuttleless looms are 60% higher than speed of non-autolooms. However, these modern machines require enhanced uniformity in the yarn compared to that required for conventional ones. It has been observed that the appearance of imperfections was 5-6 times than the suggested norms.

As an outcome of shuttleless technology, direct warping, use of splicing technology, automatic doffing and knotting systems, etc., and the extensive use of these techniques in developed countries increases their mill productivity. Weaving machines used in developed countries are having higher productivity. Mills in the developing countries have been accepting the benefits of the above techniques.

2.5.3 Composite Mill Processes

The composite mill normally has spinning, weaving and wet processing including bleaching, dyeing, printing and finishing operations. A large number of mills only do spinning. A few may do only weaving. Present trend is to have processing establishments independent of cloth production establishments, or to have one processing house which handles cloth produced by a number of mills. This is done to reap the benefits of economies of scale.

An integrated cotton textile mill produces yarn from raw cotton. The process includes steps like opening and clearing, picking, carding, drawing, spinning, winding and wrapping. No water borne pollution originates in this sequence of operations since the operations are all mechanical. The procedure of processing of raw cotton to the finished cloth includes sizing, desizing, kiering, bleaching, mercerizing, dyeing and finishing. The function of the different process stages and the activities are given below.

Table 2.15. Process Stages

Process	Function	Activity
Sizing	To impart abrasion resistance and other properties required for good weaving performance at the loom	Loaded with starch or other sizing substances
Desizing	To remove impurities like starch, gum, etc.	Acids are usually used to hydrolyse the starch
Kiering	To remove waxy and oily substances and to improve absorbancy.	Caustic soda, Soda ash, detergent etc. are used
Bleaching	To render the fabric white by removing coloured impurities	Oxidizing chemicals like peroxides and hypochlorites are used to remove the natural colouring materials
Mercerizing	To impart lustre and strength	Treated with strong caustic soda
Dyeing	To impart colour to fabric or yarn	Various salts and auxiliaries are used
Finishing	To remove appearance and handle of	–

The factors which influence the desired results in these wet processing operations depend on the chemical concentrations, duration of treatment and temperature.

CHAPTER 3

Energy profile

A study of the industry reveals that there is no systematic approach towards energy management in majority of the mills. It has also been found that a small number of mills have already taken steps that have led to significant reduction in energy consumption, whereas, a large number of mills have either not done anything or only part of what all could be done.

In the recent past, the cost of raw material i.e. cotton has also increased tremendously. Similarly energy cost has also increased rapidly assuming a sizable proportion of production cost. So most of the textile mills should try for their best to minimise their production cost and improving the quality of production by adopting the following measures:

i) Modernising their machines to achieve maximum production levels.
ii) Rationalising the workforce.
iii) Training of operators, supervisors and managers to upgrade their performance level.
iv) Adopting cost reduction measures like-
    (a) Energy conservation in process.
    (b) Minimising wastage of raw materials, downtime and other resources.
    (c) Adopting automatic/on-line control systems etc.
v) Accredition of ISO-9000 in order to qualify for export to USA & European countries.

The industry is quite energy intensive. The absolute consumption of different forms of energy for the year 1993-94 were; (i) 4 million tonnes of coal, (ii) 0.5 million tonnes of fuel oil and (iii) 8500 million kWh of electricity. The share of the energy use by the sector stands at around 9% of the total commercial energy use in the country. A pie chart giving the relative share of different forms of energy is shown in **figure 1**.

The share of energy cost has gone up from a mere 3-4% of the total production cost in 1984/85 to as high as 12-14% in 1993/94. It is expected that this trend will continue in future as well. There seems to be no alternative but to seriously pursue energy conservation activities so as to contain this alarming trend.

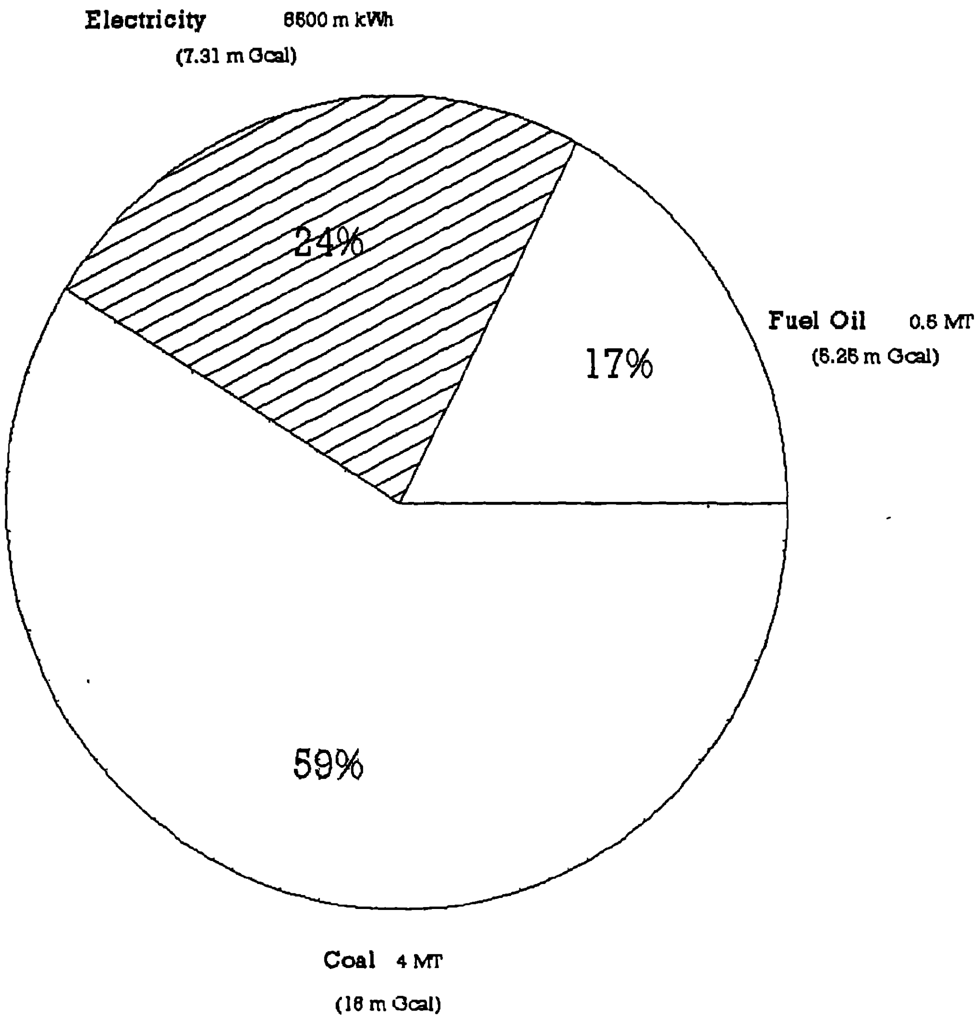


Fig. 1.01: Relative share of different forms of energy

3.1 Energy use pattern

The primary energy inputs in textile manufacture are steam and power. The requirement of steam and power varies with the following parameters :-

1. Yarn counts;
2. Yarn productivity;
3. Type of fabric (product mix),
4. Fabric productivity; and
5. Extent of wet processing (dyeing and printing).

3.2 Stage-wise process energy consumption

3.2.1 Ring Spinning

In a composite mill ring frames consume as much as 30% of the total power consumed by the mill. The consumption of power by a ring frame depends on various parameters such as spindle speed, count of yarn spun, ring diameter and lift, and a number of other machine parameters. Power consumption roughly increases at double the rate of increase in spindle speed. Even then the trend is towards higher and higher spindle speeds. This is because higher productivity outweighs the excess energy consumption making it economical to operate at higher spindle speeds. The ring frame power consumption is shown in **table 3.01**.

Table 3.01. Ringframe power consumption

Count (Ne)	Ring diameter (mm)	Lift (mm)	Spindle speed (r p m)	Av. power over doff (watts/spindle)
20^s	50.8	203 2	11000	26 25
40^s	41.3	117 8	14000	22.63

Notes Wherever necessary corrections to the above are to be given in the order mentioned below.

(a) To calculate the norm for actual operating spindle speed multiply the values by (actual speed + reference speed)

(b) To calculate the norms for lift of 203 2 mm for counts 30^s - 120^s multiply the values by 1.1

(c) To calculate norms for ring diameter of 44 5 mm for counts between 30^s to 120^s multiply the values by 1 15

(d) The above values are electrical power inputs to the motor considering 85% motor efficiency

Source: Norms for textile industry, Ahmedabad Textile Industries Research Association

3.2.2 Weaving

There are several types of weaving machines, including the conventional and shuttleless machines. Power consumption depends on the type of fabric and the type of loom. Energy used by a loom is roughly proportional to the square of the speed. Fabrics made

of finer count yarn consume more power per kg as compared to coarse count fabrics. The survey of the Deptt. of Scientific & Industrial Research, New Delhi, has observed that the **specific steam consumption ranges from 0.19 to 0.87 kg/metre of fabric** and **specific electricity consumption ranges from 0.29 to 0.59 kWh/metre of fabric.**

3.2.3 Wet Processing and Finishing

For certain machines such as cylinder drying ranges, the stenter and sizing machines, the speed of the machine must be constantly adjusted through automatic controls. The adjustment depends on the moisture regain in the fabric after drying. Power consumption for processing and finishing of cloth depends on various conditions such as the density, width and type of fabric, the machine used and the rate of processing. Proper maintenance is the main pre-requisite to ensure efficient energy use in the wet processing machines This is because of the adverse impact of corrosive action of water, chemicals and higher operating temperatures on bearings, seals, gears, guide rolls etc.

In the process department, electrical energy consumption accounts for only 20-25% of the total energy, whereas steam consumption accounts for the major portion of 80%. The requirement of electricity is mainly for providing motive power to various machines (80-90% power consumption) in a textile mill, while the rest is used for illumination, heating, etc. Steam requirement is basically for :

1 Sizing and conditioning of yarn and space heating in manufacturing sections; and
2. Elevating the temperature of dyes and chemicals, drying operations, resin treatment, drying and heat setting operations.

Textile yarns and fabrics contain natural as well as added impurities in their raw state, which hinder the wetting, and in imparting colour to the material. In case of cotton, one has to remove wax, proteins, pectins and natural colouring matter through a series of energy consuming processes that may require up to **7170 Kcal/kg of the fabric**. This will be equal to about **11 kg of steam or 2.5 kg of coal per kg of processed fabric**.

The overall specific electricity consumption for spinning and composite mills are shown in **table 3.02**

Table 3.02. Specific Electricity Consumption

Type of Mill		Units/kg	Units/spindle shift	Units/Loom shift
	Max	6 60	0 420	-
Spinning Mills	Min.	2 58	0 291	-
	Avg	4.63	0 344	-
	Max.	19 51	1 120	103 00
Composite Mills	Min	6 70	0 359	19.81
	Avg	11 76	0 632	35.29

In the conventional preparation of cotton and cotton woven fabrics energy can be conserved in each of the process steps. A brief description of such step alongwith specific energy use in each of these steps are provided below.

3.2.4 Singeing

Surface fibers are removed by passing the fabric over a gas flame. The energy required is of the order of 70-95 Kcal/Kg of the fabric processed

3.2.5 Desizing

Size is removed from a fabric either by swelling it in water or breaking it down by acids or by enzymes. The most common sizes are starch based. However, starch and starch derivatives do require breaking down to render them soluble. Whichever method is used to remove the size, the appropriate reaction is time and temperature dependent, so that in practice, a period of heating or a longer dwell in the cold is necessary. This may be followed by either a washing-off process or the next stage of preparation. If washing is carried out, an energy use of about 1200 Kcal/Kg is required

3.2.6 Scouring

This is an alkaline treatment that saponifies and removes fats and waxes, and solubilities pectic cell-wall material in the cotton fibre. This process is also time and temperature dependent, and the way in which it is carried out varies from approximately 24 hours in cold to 1-2 min at 130°C. In most cases scouring is followed by washing-off to remove impurities. Typical results suggest that the energy requirement for scouring cotton fabric is about 1430 Kcal/Kg. Washing-off requires an additional 1200-1400 Kcal/Kg.

3.2.7 Bleaching

Although at this stage fabric is cleaner and wettable, it is coloured. Oxidative bleaching is carried out to improve the ground colour of the fabric and to provide a uniform base for

subsequent processes. The chemical most commonly used is hydrogen peroxide, though sodium hypochlorite and sodium chlorite are also used.

Hence, the energy requirements are similar, and may amount to 1200 Kcal/kg. Washing-off is an important part of the processing, again requiring 1200 Kcal/Kg. This energy requirement is dependent on the water consumption in the process and can also be significantly influenced by the use of a heat exchanger to recover heat from the effluent.

3.2.8 Drying

The final washing-off is followed by drying. This latter stage is usually carried out on cylinders, and varies in energy requirement between 450 and 880 Kcal/Kg. This variation is, in part, a reflection of variation in fabric width, weight and moisture content.

Overall, the preparation process makes a significant contribution to the energy consumption in a dyeing and finishing works where cotton or polyester/cotton fabrics are processed. As stated above, about 7170 Kcal/Kg of energy are used in processing such fabrics. Water consumption is also significant.

It is clear from this information that modifications in the separate stages, resulting in reduced energy consumption, are highly desirable, provided production rates and fabric quality do not suffer.

CHAPTER 4

Energy conservation opportunities

An effective way of saving energy in textile process houses would be to reduce wet pick up by fabrics during processing and to carry out processes using low mother liquor.

An overview of waste heat recovery possibilities for the Indian Textile industry is shown in **table 4.01**

A consolidated list of various energy saving measures that are applicable for the textile industry (both thermal and electrical energy saving measures) is provided in **annexure 4.01**.

4.1 Major energy saving opportunities

Some selected details about the major energy saving opportunities are discussed below.

4.1.1 Installation of Radio Frequency Drier

When a voltage of high frequency is applied to water dipoles, the polarity of the molecules change several times in a second. The effect of this rapid oscillation of dipoles is to generate heat within the dipoles itself which leads to the evaporation of water, but the textile materials being electrically symmetrical will not generate any heat, their temperature will rise to the level of water temperature due to intimate contact with water.

The approximate investment would be Rs 80 lakhs to install a radio frequency drier with annual savings of about 30-50 lakhs.

4.1.2 Use of smaller wrap diameter spindle

The weight of the spindle is another factor which influences the energy consumption. If the spindle is heavy, the reaction at the bearing is heavy and therefore the energy consumption is also heavy. The energy consumption goes up as the spindle weight increases. The approximate investment would be Rs 35 lakhs with an annual savings of about 3-4% energy used in ring frames.

Table 4.01. Overview of the waste heat recovery systems

S No	Waste heat source	Waste heat recovery system	Recovery efficiency (%)*	Total investment (million Rs)	Payback period (years)
1	Hot flue gases in Boiler plant	Plain or Finned tube Economiser	40-60	1 8-2 3	1 - 2
2	Condensate from steam consuming machines	Condensate return piping, system	70-80	0 35-0 7	< 1
3	Boiler blowdowns	Flash vessel and heat exchanger	60-80	0 1-0 2	< 1
4	Hot water discharge vapours from the last effect of the Barometric Condenser of caustic recovery evaporator plant	Auxiliary barometric condenser	70-80	0 16-0 21	< 1
5	Hot water vapours from the Ager	Ager exhaust heat recovery system	< 90	0 1-0 14	< 1
6	Hot exhaust gases from Stenter	Packed tower	~ 50	0 19-0 24	~ 1-2
7	Hot exhaust gases from the D G Set	W H R boiler	~ 50-60	0 47-0 82	~ 2
8	Hot flue gases of thermic fluid heater	W H R water heater/thermic fluid heater	~ 40-50	0 17-0 22	< 1
9	Hot liquor discharge from H T H P Beam dyeing machine	W H R water heater	~ 50	0 12-0 19	~ 2
10	Hot liquor discharge from Jet dyeing machine	W H R water heater	~ 50	0 09-0 15	~ 2
11	Hot liquor discharge from Kiers	W H R water heater	~ 50	0 1-0 14	~ 2

* to the ambient temperature

4.1.3 Use of single stage bleaching process

The scouring-cum-peroxide boiling using suitable stabiliser estimated to reduce the requirement of various utilities and energy upto 60%.

4.1.4 Use of resin finishing

In rapid cure technique of resin finishing suitable mixed catalyst system is used. It permits drying-cum-curing with an estimated energy savings of about 40-50%.

4.1.5 Use of low energy bleaching process

This is a scouring-cum-bleaching formulations using suitable azeotropic/emulsion. The estimated savings of 60-70% in utilities and energy.

4.1.6 Rapidogen development

This is a dry-heat fixation technique using suitable acids liberating compound operating under curing conditions. The energy savings are estimated in case of rapidogen printing alone and alongside printing with pigments 40% and 60% respectively.

4.1.7 Use of low temperature curing of pigments prints

Highly active catalyst, viz., ammonium sulphamate is used in this process. 50% reduction in time of curing or temperature by about 30-40%.

4.1.8 Use of foam technique of printing and finishing

In this technique, suitable foaming agents and stabilisers for low wet pick up applications are used. The estimated energy savings is 50-60%.

4.2 Use of renewable energy

In addition to the measures mentioned above, there is a possibility of utilising renewable source of energy in the textile industry, specifically solar thermal applications for generating low grade heat.

Although industrial process heat requirements for a textile industry covers a broad temperature range, a significant amount of heat is used at temperature which can be provided by currently available commercial solar collectors. With the advances in technology the costs are likely to reduce and the efficiency would improve. Solar energy is inexhaustible and pollution free source of energy which can be harnessed to give hot water, hot air or steam by using various forms of solar heaters like flat plate and concentrating collectors.

Table 4.02 and **4.03** present the estimates of process water flow rates and temperatures for fabric containing cotton and for 100% synthetic products.

Table 4.02. Estimates of process water flow rates and temperatures for fabric containing cotton

Operation	Water flow rate (L/kg cloth)	Typical water use temperature (°C)
Slashing	0 5 - 8.5	28-48
Scouring and/or Desizing	50 - 290	60-94
Bleaching	2.5 - 125	68-94
Mercerizing	8 5 - 83	65-94
Dyeing and rinsing		
Basic dyes	167 - 334	*
Developed	167 - 334	*
Direct dyes	8 5 - 208.5	*
Napthol dyes	8 5 - 167	*
Sulfur dyes	8 5 - 167	*
Vat dyes	8.5 - 167	*
Dispensed dyes	8.5 - 300	*

If kettle (beck) dyed 38°C fill and controlled heating to use temperature If continuous dyeing· 94°C.

Table 4.03. Estimates of process water flow rates and temperature for 100% synthetic products

Operation	Fibre	Water flow (L/kg cloth)	Typical water use temperature (°C)
Slashing	All	0 5 - 8 5	28-60
Scour	- Nylon or Acrylic	50 - 67	48-72
	- Polyester	17 - 33	60-94
Dye	Nylon or Acrylic or Polyester	17 - 33	38-90
Scour and	- Rayon	17 - 33	38-94
Dye	- Acetate	33 - 50	38-94

4.2.1 Feasibility of using solar energy in Textile Industry

Tables 4.02 and 4 03 present the estimates of process water flow rates and temperatures for fabric containing cotton and for 100% synthetic products respectively. A summary of the process water/energy use for fabric dyeing and finishing for a typical mill is shown in **table 4.04**

Table 4.04. Annual Consumption of Water in process stages

S No.	Operation	Total water use per year (x 10⁹ L)	Temp. range (°C)
1.	Synthetic Fabric rinsing after dyeing	22.7	50-72°C
2	Carpet rinsing after dyeing	15 1	50-72°C
3	Cotton rinsing after dyeing	11 4	50-72°C
4	Cotton scouring and bleaching	7.6	90-100°C
5	Cotton dyeing	15.1	90-100°C
6	Atmospheric carpet dyeing	15.1	90-100°C
7	Synthetic fabric scouring	9 5	90-100°C
8	Cotton mercerizing	7 6	90-100°C
9	Synthetic fabric dyeing	26.5	130-180°C

It may be noted that the single maximum requirement of process energy is for cotton scouring and bleaching which requires about $2x10^{10}$ gallons ($7.57 \times 10^7 m^3$) of process waste water (at 90-100°C) per year.

In textile industry, 80% of energy used is utilised in wet processing, with temperatures ranging from 40°C to 140°C. In the utilisation of Solar energy for heating of water, the problem of lower temperature differentials were faced when shell and tube type heat exchangers suggested. The need of higher temperature differentials resulted in higher temperature of operation and consequent loss of efficiency in the Solar systems with such heat exchangers. This led to search for counterflow type heat exchangers with tube in tube construction. The actuals achieved were 65°C inlet and 30°C outlet for the heating stream and 62°C and 25°C for the heated stream.

Success of this system resulted in large scale application of heat exchangers in the Solar water heating systems for use with water having high dissolved solid content and large temporary hardness, and hundreds of installations have since been put up with these heat exchangers.

4.3 Constraints for implementing energy saving measures

Although cost of energy constitutes a large part of production cost and also the payback period in this type project is quite attractive still the management does not give priority to install energy efficient system. They give main priority to the production machineries which will give them more production at any cost. Of late, they have started thinking of cost reduction improving the worker' skill by proper training, proper maintenance system etc. Moreover, it is our observation that if there is any investment in energy area there is no system of proper monitoring and control of the energy consumption. This may be due to lack of management support in building a proper infrastructure to set up a energy cell who could regularly undertake energy conservation activity. As a result, proper return of

the money through energy saving can not be properly quantified. Government of India (Ministry of Power, IDBI, PCRA, EMC, etc) have announced some incentive and soft loans for energy conservation activities. But these incentives are not availed by a large section of mills due to many factors.

We would suggest the following steps which if implemented properly could be of great benefit to the industry and country as a whole for making energy conservation assistance scheme more successful.

1. There should be a detailed survey of different categories of mills which will analyse the following parameters:

   (a) Financial condition of the mill.
   (b) Technical performance of the mill with respect to productivity and quality improvement for the last few years.
   (c) Evaluation of existing machinery conditions.
   (d) Evaluation of existing performance of the mill and evaluation of the energy equipments.
   (e) Preparation of energy index for different categories of mill.

2 During project finalization stage for setting up a new mill or expansion and modernization projects, the financial institutions before finalizing the loan, should refer the entire project proposal to an expert body of energy system who could suggest whether the machineries conform to energy efficient levels or not and give their opinion so that the machineries selected give maximum energy savings.

   Similarly, for selection of equipments for utilities i.e., boiler, transformers, motors, drives and controls, D.G sets, capacitors, lighting systems, humidification and air conditioning system, pumps, compressors, etc. should also be referred to the energy expert body for energy efficiency before sanctioning of loans

3. In order to encourage the progressive mills who have already done a good work in the energy conservation area like installation of cogeneration system, high efficiency boilers, energy efficient motors and drives and other energy efficient system implementations, they should be given some incentive by the government and other financial institutions This will also encourage other units to go for energy efficient systems.

Old Mills

The textile mills which are operating with most of the old machineries and whose financial position is not so good have been classified as old mills. The performance of these mills had not been quite satisfactory due to several factors. But in order to survive in today's competitive world, they have to modernize and for which they have to seek financial assistance from financial institutions. There may be other reasons why old mills are showing disinterest towards modernization - firstly the type of products they manufacture i.e. coarse and medium yarns which have a good market in decentralized segment (Powerloom and Handloom); which does not call for stringent quality requirements; secondly the type of work-culture (union activity), dearth of adequate long-term modernization planning etc.. So over the long years the overall technical and other condition of the mill have deteriorated to such an extent that it would require a huge investment to get the mill modernized. So some managements would prefer to set-up a new mill than to make large investment in an old mill. But this reasoning may not be true all the time. A progressive management with a good modernization scheme and right approach and intentions can turn the tide and create a situation where sick units may become profitable. Many of the progressive textile mills have their own training cell and it is good sign that more and more textile mills have begun to realize the urgent need of proper training and investing in training is not a bad investment, which they used to think a few years ago.

Chapter 5

Environmental aspects

The pattern of production of cloth in the textile industry shows a very wide variation with regard to types of fabrics produced and their quantities. Obviously, the environmental impacts will also vary with the process. The textile industry is typical in the sense that a large number of small textile processing units are scattered all over the country. Being mostly under small scale sector, these units generally do not have any pollution control equipment and are thus responsible for high levels of pollution in certain parts of India. Large number of such units are located in Ahmedabad, Surat and Jetpur in Gujarat, and in Pali and Balora in Rajasthan.

5.1 Environmental Pollution

An assessment of the different types of pollutants and the possible mitigation technologies are detailed in this chapter.

5.1.1 Type and Source of Pollution

5.1.1.1 Solid wastes

Solid wastes in general is considered as a major problem in the textile industry. Wastes are generated in the preparation of the raw cotton, spinning and weaving sections of the various wet processes and the finishing of the fabrics. The boiler house burning coal also produces a large quantity of cinder and fly ash. Fairly large quantities of sludges are produced from chemical and biological treatment plants. Different types of solid wastes that are generated from major sections of the mills are outlined below.

Blow Room. It generates solid wastes mainly in the form of dust particles adhering to the fibers, seed coating, seeds, and cotton fibers all of which are removed from the blow room as trash material. Processes have been developed for conversion of the blow room dust into disposable material by composing or as a fuel material for burning/heating in a briquette form.

Carding and Combing. The waste comprises of 50 to 55 percent short fibers. During combing the short fibers are removed. The good quality fibers are separated and baled for use in the blanket mills.

Spinning & Weaving. The spinning section also generates some amount of cotton fibers of good quality and they are not converted into yarn but are salvaged for reuse in other ways.

The weaving section and other process houses also generate large quantities of imperfect or faulty cloth in the form of rejects and of seconds quality and also rags and felts, all of which are recovered and marketed as such.

Solid residues are generated from the heat set and the tenter frames due to degradation of the finishing chemicals and from solvent recovery units. Solid wastes are generated in the form of sludges from the physicol-chemical and biological treatment of the textile waste waters. These sludges may contain heavy materials, dyestuffs chemical precipitation solids and biomass material. The waste water treatment sludge constitutes nearly 10-12 percent of the solid wastes in a textile mill.

Another type of solid wastes consists of bags or metallic containers which contain material residues, and are thrown away These may be salvaged for recycling and reuse.

5 1 1.2 Liquid wastes

The main source of pollution from the textile industry is by way of liquid effluents. The sources of waste water from a textile mill are from designing, kiering (scouring), bleaching, rinsing, mercerising, dyeing, and printing sections Waste streams are also generated from the various utilities such as boiler house, cooling tower blow down, water treatment plant, floor washings and sanitary waste water. The quantity of waste water from other sections is quite small as compared to waste water generated from the scouring, rinsing, and washing operations. The bleaching, dyeing and printing sections contribute maximum effluent It is estimated that 12-65 liters of water is required for processing one metre of cloth which produces about 20-30 grams of BOD. Volume of waste water varies from mill to mill and lies in the range of 35-520 liters per kg of cloth produced with an average figure of 170 liters/kg Waste water from the textiles industries are generally coloured, high in BOD, COD and suspended solids, highly alkaline and at a fairly high temperature Waste water characteristics are highly variable and sometimes contain toxic chemicals and metals.

The combined waste water from an integrated textile mill contains a large variety of organic and inorganic chemicals such as dyes, pigments, and other chemicals used in the different processes such as starch, carboxy methyl cellulose, dextrine soap detergents and heavy metals like chromium The typical composition of process waste water from different section is shown in **table 5.01**

Table 5.01. Composition of the process wastewater

Unit process	Composition of the waste water	Characteristics of waste water	Effluent generated
Sizing	Starch and softener originating from the washing	High BOD	Due to spills and floor washing, produced about 5-10 cu.m. per week
Designing	Starch, glucose, CMC, PVC resins, fats & waxes	High BOD 35 to 50% of total CMC & PVA do not exert a high BOD, neutral pH, high total solids	About 1100-1200 cu.m./day effluent produced, which is about 30% of the total pollution load from the mill.
Kiering	Caustic soda, waxes, grease, Soda ash, Soda silicate and cloth pieces	Strongly alkaline, coloured, high BOD cloth pieces (30% of total), high total solids, high temperature	
Bleaching	Hypochlorite, chlorine caustic soda, H_2O_2 acids	Alkaline contributes fairly high BOD, high solids	About 220-290 cu m /day effluent produced, contributing 10% of the total pollution load
Mercerising	Caustic soda	Strongly alkaline, low BOD (less than 1% of total) high sodium content, low solids	Sodium hydroxide is recovered and the water is recycled
Dyeing	Various dyes, mordant and reducing agents	Strongly coloured high BOD and COD	400-500 cu.m /day
Printing	Various colours, starch gums, China clay, mordants, acids metallic salts	Highly colored, fairly oil, high BOD and oil	
Finishing	Traces of starch tallow, common salt, Na_2SO_4, etc	Slightly alkaline, low BOD	

5.2 Environmental norms

Table 5.02. Environmental standards

Parameter	Standards
	Concentration not to exceed, milligramme per litre (except for pH and bioassay)
Common	
pH	5 5 to 9
Suspended solids	100
Bio-chemical oxygen demand, 5 day	150
20°C	10
Oil and grease	90% survival of fish of after 96 hours
Bio-assay test	
Special.	
Total chromium (as Cr)	2
Sulphide (as S)	2
Phenolic compounds (as C_4H_2OH)	5

The special parameters are to be stipulated by the Central Board in case of union territories and State Boards in case of states depending upon the dye used in the industry. Where the industry uses chrome dyes, sulphur dyes and or/phenolic compounds in the dyeing/printing process, the limits on chromium of 2 mg/litre, sulphides of 2 mg/litre and phenolic compounds of 5 mg/litre respectively shall be imposed.

Where the quality requirement of the recipient system so warrants, the limit of BOD should be lowered upto 30 according to the requirement by the State Boards for the states and the Central Board for the union territories.

5.3 Containment strategies

Some recovery techniques and strategies to contain pollution are discussed below

(i) **Caustic Recovery.** Caustic is used in the process of mercerisation and is subsequently discharged with the waste water. It is possible to collect the caustic bearing effluent at one place, remove its impurities and then make up its concentrations to the requisite level. Thereafter, it can be reused in the process thus saving the recurring cost of caustic.

(ii) **Recovery of Sizing agents.** The synthetic sizing agents from desizing unit waste liquor can be segregated by chemical precipitation with metallic salts e.g aluminium sulphate and its conversion into sodium salt by treatment with caustic soda

(iii) **Recovery of dyes.** In the vat dyeing process only about 65 to 75 percent of the dye is absorbed by the fibre and the remaining is drained out. This category of dyes may be recovered and reused in the same dyeing process. Similarly, bright coloured lacquers etc. may be recovered from basic azo and reactive dye waste liquors by precipition of their metallic derivatives.

(iv) **Use of steam agers.** For fixing of colour, silicate process is normally adopted in textile dyeing and printing houses. About 2-10 kg per than (1 thaan = 80m) of sodium silicate is used for fixing colour After the colour is fixed, the effluent containing sodium silicate is discharged. If this process is replaced by steam agers, in which, the colour is fixed using steam, the quantity of sodium in the waste waters can be reduced by about 80 percent. The colour fixed by steam agers is better than that fixed silicate process. Also, it works out to be cheaper than silicate process

Resorting to caustic recovery and steam agers would help reduce sodium content in the effluents of these units.

(v) **Conservation of water.** If the quantity of water used in the process is less, reduced quantity of waste water will have to be treated prior to discharge. Keeping this point in view, the processes where water use can be minimised have to be closely studied so that less water is utilised i.e., per unit of production. Reuse of water can also be resorted to as a mean of conservation. For example, use of rinse water from one operation for make up water in second operation. This results in a net reduction in water use for total production. In water use planning, one has to review various processes and their water quality requirement and then tailor the uses to the minimum quantity for each process. This can involve in collection of all clean water for reuse without treatment or with only minimum treatment.

5.4 Methods of Waste Water Treatment

Textile mill waste water is readily amenable to treatment in combination with sewage. Sewage not only dilutes the wastes, but also supplies the requisite quantities of Nitrogen and Phosphorus, which are essential for biological treatment. The treatment is done in three stages i.e., (1) Primary treatment (2) Secondary treatment and (3) Tertiary treatment.

5.4.1 Primary Treatment

Prior to discharge to the main sewers/drain, it is desirable to provide primary treatment like neutralisation, sedimentation etc. is provided by individual units to reduce the ultimate load on the terminal treatment facility. Various stages in primary treatment are detailed below:

(i) **Segregation.** Some textile waste liquors such as desizing - mercerising washes, Kier discharges, dyeing and printing wastes are quite concentrated and may contain substances that will interfere with the operation of the treatment unit. It is essential to separate them from the main flow and distribute them uniformly so that their effect on the main stream be reduced.

(ii) **Screening.** Screening of the effluent helps in the removal of fibrous materials, rags, solids etc. thus minimising the choking up of water ways. Self-cleaning device will reduce the frequency of screen changing thus increasing the overall efficiency of the screening process. Most commonly, vibrating screens are used for removal of short fibres.

(iii) **Equalization.** For this process, a storage tank, pond or lagoon with a capacity equivalent to one day's effluent is desired. Uniform treatment will help the further

treatment and make it more efficient with an advantage of removal of substantiative percentage of BOD. If this equalization system is provided with the needed aeration, the pre-aeration will be beneficial to prevent septic condition and to oxidize the easily oxidizable substances such as hydrogen sulphide.

(iv) **Neutralization.** The effluent from a textile unit having mercerization plant, can be neutralized if it is brought in contact with wash liquor from polyester or cotton carbonization units. Textile units having both mercerization as well as carbonization plants normally discharge an effluent having a pH range of 6.5 - 8.0. In such cases no acids or alkali agents need to be added to correct the pH level. Otherwise, the alkalinity level is usually brought down to neutral by adding Hydrochloric acid. Sulphuric acid or compressed carbon-di-oxide gas.

(v) **Coagulation and Sedimentation.** The colloidal solids which demand oxygen and produce turbidity, can be effectively removed by chemical coagulation followed by sedimentation, for the reduction of BOD and colour. Normally, chemicals like iron salts, alum, lime and calcium chloride are used for this purpose. To make the process of sedimentation easy and effective pH between 6 to 7 will have to be maintained. Most commonly, coagulants are added with the help of automatically controlled device quite rapidly so that they are well dispersed before the precipitation takes place and this is followed by slow stirring over a long period of time so as to allow the flocs to settle down.

The major benefit of proper primary treatment can be effective in reducing the pollution load on the secondary treatment plant thereby increasing the efficiency of the system. Also, statutory requirements laid down for discharge of effluents can be partially achieved during this stage itself.

5.4.2 Secondary Treatment

Secondary treatment involves removal of solids from the waste water followed by biological treatment. The effluent is subjected to coagulation, flocculation and sedimentation for the removal of colour, colloidal and heavier solids Alum and ferrous sulphate are the most commonly used coagulants. Chemical treatment with lime and gypsum is also being done to remove colour, suspended solids, and fibers from cotton textile mill wastes. This chemical treatment removes 55-95% of colour but the BOD removal is only in the range of 40-50%. The combined textile mill wastes are then treated by conventional aerobic biological treatment methods like the trickling filters, activated sludge process, rotating biological contact reaction, extended aeration and aerated lagoons.

The results of chemical treatment of cotton textile waste using alum and $FeSO_4$ are given in **Table 5.03**.

Table 5.03. Result of chemical treatment

Status of Waste	BOD mg/L	% Reduction	COD mg/L	% Reduction	Dose mg/L
Raw waste	1 25	-	2345	-	475
Treatment with alum	166 00	34	360	29	300
Treatment with $FeSO_4$	34 00	39	215	60	-

The high cost of chemicals, which makes this treatment an expensive process chemical treatment results in 65 to 95 percent colour removal and 30 to 50 percent reduction in BOD.

5.4.3 Tertiary Treatment

Tertiary treatment is employed to reclaim water from the process waste water. The effluents from the conventional primary and secondary treatment do not meet the quality standards of the process water. For tertiary treatment, activated carbon absorption, reverse osmosis, and ion exchange methods are generally employed. Reverse osmosis results in excellent colour removal whereas ion exchange is suitable for treatment of highly alkaline waste stream. Activated carbon absorption is used for removal of organic materials, particularly soluble dyes.

CHAPTER 6

Conclusion

In the present study, a detailed assessment was carried out with regard to cotton textile industry in India. The sector is characterised by a large number of old mills employing outmoded technology. The share of energy cost has risen steadily over the years and presently stands at around 12-15% of the total production cost. At an aggregate level, there is general apathy towards energy conservation and a total lack of energy management at the plant level. Overall energy saving potential estimated in this sector is around 23% of the total energy use. For the survival of the sector and to remain competitive, there seems to be no alternative but to pursue energy conservation activities and replace old technologies with new/efficient ones.

A comparative assessment of the textile sector indicates that it is a right candidate to provide support under the phase-II of the ESP programme. There are also many progressive mills in the sector engaged in modernisation and expansion of the units. A list of units where energy/environmental audits and feasibility studies could be carried out is provided in **Annexure 6.01**. A select list of organisations involved in providing technical support to the industry is given in **Annexure-6.02**.

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Annexure 4.01

Broad approaches for electrical energy conservation

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1. **Motors and Drives**
   - (a) Selection of proper motor rating
   - (b) Synthetic tapes for ringframes
   - (c) High efficiency motors
   - (d) Variable speed drive for fans and pumps
   - (e) Use of flat belt in place of V-belt
   - (f) Use of nylon belts in place of leather belts
   - (g) Narrow width spindle tapes in ringframes
   - (h) Advanced variable speed drive system

2. **Machine Design Approaches**
   - (a) Smaller spindle wharves diameter for ringframe
   - (b) Use of tin pulley in place of tin roller
   - (c) Use of light weight spindles in ringframes
   - (e) Optimization of picking mechanism in looms
   - (e) Swell release mechanism for looms

3. **Tribological Approaches**
   - (a) Use of energy efficient spindle oil and other lubricants
   - (b) Automatic lubrication system
   - (c) Effective lubrication management

4. **Better Operation and Maintenance**
   - (a) Proper lubrication of machine parts
   - (b) Overhauling of ringframes
   - (c) Spindle-centering at ringframe
   - (d) Adjustment of pulley alignments at ringframe
   - (e) Loom tuning
   - (f) On-line production monitoring system

5. Humidification

(a) Roof cooling
(b) Isolation of hot exhaust from machines
(c) Isolation of motor heat
(d) Minimizing heat from building/windows
(e) Size recipes for low humidity weaving
(f) Cell type air washer
(g) Use of automatic humidity controller
(h) Seasonal control of fans/pumps
(i) Use of FRP fan-blades in place of metal casting

6. Shorter and Modified Wet Processing

(a) Reducing drying operation
(b) Catalytic system for processing at lower temperature
(c) Energy economic processes
(d) Adoption of quick treatment processes
(e) Reducing wet pick-up

7. Better Control and Management of Utilities

(a) Electrical load management
(b) Minimizing electrical distribution losses
(c) Power factor improvement/controllers
(d) Low energy lighting and proper control
(e) Optimization of compressed air energy usage
(f) Re-use of water and control of water system
(g) Section-wise energy monitoring
(h) Prepare their own norms and compare it with standards
(i) Microprocessor based electrical energy monitors
(j) MDF controller
(k) Foil wound efficient transformers

Broad Approaches for Thermal Energy Conservation

1. **Boiler and Thermic Fluid Heaters**
   - (a) Correct operational practices
   - (b) Use of economizers
   - (c) Combustion control and instrumentation
   - (d) Fluidised bed combustion boilers

2. **Machine Design Approaches**
   - (a) Energy efficient stenters (dryers)
   - (b) Energy efficient washers
   - (c) Limited application techniques
   - (d) Exhaust control in dryers
   - (e) Modification in beam dyeing machines
   - (f) Temperature controller in jiggers
   - (g) High pressure squeezing methods
   - (h) Vacuum extraction techniques

3. **New Chemical Processing Approaches**
   - (a) Low temperature scouring and bleaching
   - (b) Wet mercerisation
   - (c) Wet dyeing
   - (d) Dyeing with single dyestuff for blends
   - (e) Pad-batch and pad-develop dyeing methods
   - (f) Low temperature catalytic curing
   - (g) Low temperature resin finish
   - (h) Roberto-rolls for reducing wet pick-up
   - (i) Foam technology
   - (j) High pressure squeezing

4. **Waste Heat Recovery**

   (a) Condensate return
   (b) Heat recovery from thermic fluid heater
   (c) Heat recovery from boiler blow-down
   (d) Flash steam recovery
   (e) Recovery from stenter exhaust
   (f) Recovery from jet dyeing effluent
   (g) Recovery from beam dyeing effluent
   (h) Recovery from ager exhaust
   (i) Recovery from jacket cooling of diesel
   (j) Recovery from diesel exhaust

5. **Alternate Energy Source**

   (a) Solar energy
   (b) Biogas from willow dust
   (c) Briquetted fuel
   (d) Agro-waste

6. **Space Heating**

   (a) Eliminating use of steam for space heating
   (b) Approaches for more efficient heating of humidification

7. **Efficient Steam Distribution and Lagging**

8. **Steam Using Machinery**

   (a) Proper selection and use of steam traps
   (b) Use of pressure reducers for direct steam usage
   (c) Heat balance studies and operational improvements·
      (i) Dryers
      (ii) Liquor heating machines
      (iii) Steamers
      (iv) Heat-setting machines
   (d) Mangle audit
   (e) Fuel audit and diagnostic studies

9. Instrumentation and Control

(a) Fuel, steam and water monitoring

(b) Temperature control on liquor-heating operations

(c) Steam cut-off devices on idling machines

(d) Water cut-off devices on idling machines

(e) Exhaust control systems

10. Microprocessor Based Energy Monitoring System

11. Cogeneration System with D.G. Sets

12. Cogeneration System with Boilers and Turbines

Annexure 6.01

List of selected units for energy and environment audit

S.No.	Address	Contact perons	Tel.	Fax
1	Oswal Cotton Spinning Mills G T Road, Jugiana Ludhiana - 141 120	Mr R K Shahi, Chief General Manager	-	0161-670930
2	Shreyans Spinning Mills Vill Bholpur, P O Sahabana Chandigarh Road Ludhiana - 141 123	Mr B S Malli, Chief Executive		0161-670315
3	Vardhman Spinning & General Mills Ltd Chandigarh Road Ludhiana - 141 011	Mr V K Goyal, General Manager		0161-662542/664541
4	JCT Limited G T road Phagwara - 144 401	Mr Raj Mohan Singh, General Manager		01824-61191
5	Arvind Mills Ltd Navoda Road Ahmedabad - 380 025 (Guj)	Mr Samveg A Lalbhai, Managing Director		
6	Binny Limited Textile Division Buckingham & Carnatic Mills Perambur Barracks Madras - 600 012	Mr P R Jeevankumar, Chief Engineer		044-589034
7	Indo Rama Synthetics (I) Ltd Pithampur			
8	Hindon River Mills P O Hindon Nagar Dasna Ghaziabad - 201 002 (U P)	Mr Gajendra Jain Chief Executive		011-8-750018
9	Rajasthan Textile Mills Pachpahar Road Bhawani Mandi (Rajasthan)	Mr N.M Gupta, President		07433-2354

S.No.	Address	Contact perons	Tel.	Fax
10.	Siddhartha Super Spinning Mills Ltd. Nihla Khera, Nulagarh Distt. Solan Himachal Pradesh	Mr H.C. Jain, Chief Executive		01795-3145
11.	Winsome Textile Indus. Ltd., 1, Industrial Area Baddi - 173 205 (H.P)	Mr O.P. Bhargava, Chief Executive		01795-4287
12	Jayshree Textile Mills Rishra, Hoogly (W B)			
13	Jiyajee Rao Cotton Mills Ltd Birlanagar Gwalior - 474 004 (M P)			
14	Kesoram Industries Ltd Textile Section Garden Reach Road Calcutta - 700 024			

Annexure 6.02

Consulting organisations in the field of textile sector

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1. Ahmedabad Textile Industry Research Association
   P.O. Polytechnic
   Ahmedabad - 380 015

2. Bombay Textile Research Association
   Lal Bahadur Shastri Marg
   Ghatkopar (W)
   Bombay - 400 086

3. Northern India Textile Research Association
   Sector 23, Raj Nagar
   Ghaziabad - 201 001

4. Textile & Allied Industry Research Organisation
   Kalabhavan Premises
   Baroda - 390 001, Gujarat

5. Department of Textile Technology
   Indian Institute of Technology
   Haus Khas
   New Delhi - 110 016

6. South India Textile Research Association (SITRA)
   Coimbatore Aerodrome
   P.O. Coimbatore - 641 014
   Tamil Nadu

7. Man Made Textiles Research Association (MANTRA)
   Ring Road
   Surat - 395 001, Gujarat

Mills data, observations and energy conservation measures

Performance evaluation with respect to production and energy is summarised as follows:

Unit : The Technological Institute of Textile & Sciences, Bhiwani, Haryana

Process	Composite	Spindle Capacity	17472 nos	
Commissioning Year	1943	Yarn Prod	3757	ton/yr
Base Year	1993-94	Cloth Prod.	94 38	lakh m/yr
Turnover (Rs crores)	20.2	Total electricity	10 27	GWh/yr
		Total thermal	20300	Gcal/yr

	Annual Consumption		Annual Production	
Year	Electrical (GWh)	Thermal (Gcal)	Yarn (ton)	Cloth (lakh m)
Base year 1993-94	10 27	20300	3757	94 38
1992-93	9 79	18770	3763	122 28
1991-92	8.5	15700	3421	119 83

Unit : APM Industries Ltd. (Unit Orient Syntex), Bhiwani, Haryana

Process	Spinning		Spindle Capacity	20960 nos.	
Commissioning Year	1980		Yarn Prod	3328	ton/yr
Base Year	1993-94		Cloth Prod.	Nil	lakh m/yr
Turnover (Rs crores)	46 6		Total electricity	10.47	GWh/yr
			Total thermal	11635	Gcal/yr

	Annual Consumption		Annual Production	
Year	Electrical (GWh)	Thermal (Gcal)	Yarn (ton)	Cloth (lakh m)
Base year 1993-94	10 47	11635	3328	Nil
1992-93	9 76	8176	2963	Nil
1991-92	8 73	7776	2709	Nil

Avg count	31 24 (synthetic mill)	
UKG	91-92	3 22
	92-93	3 29
	93-94	3 15 - 0 456
Prod	92-93	9 4% prod increase 11 8% power increase
	93-94	12 3% power increase due to modernisation & energy cons.
Employee/1000 spindles	60	
Turnover 93-94	Rs 46.6 crores	

Unit : Vardhman Spinning & General Mills Ltd., (Ludhiana), Punjab

Process	Spinning	Spindle capacity	61612	
Commissioning Year	1965	Yarn Prod	13456	ton/yr
Base Year	1993-94	Cloth Prod.	Nil	lakh m/yr
Turnover (Rs crores)	181 3	Total electricity	36 092	GWh/yr
		Total thermal	18629	Gcal/yr

	Annual Consumption		Annual Production	
	Electrical	Thermal	Yarn	Cloth
Year	(GWh)	(Gcal)	(ton)	(lakh m)
Base year 1993-94	36 092	18629 0	13456	Nil
1992-93	38.86	11644.0	12505	Nil
1991-92	38.38	7142 6	12114	Nil

Avg. count	20 5 (Cotton-Synthetic-Worsted)		
UKG (units per kg)	91-92	3 17	USS
	92-93	3 11	
	93-94	2 68	0 482
	92-93	Prod increased by 3 2%	
		Power increased by 1 2%	
	93-94	Prod. increased by 7.7%	
		Power increased by 7 1%	
Employee per 1000 spindles	53.6		
Annual Turnover	Rs 181 3 crores		

Unit : Bhiwani Textile Mills, Bhiwani, Haryana

		Spindle capacity	22936 nos.	
Process	Composite	Yarn Prod	3575	ton/yr
Commissioning Year	1964	Cloth Prod.	Nil	lakh m/yr
Base Year	1993-94	Total electricity	21 19	GWh/yr
Turnover (Rs crores)	77	Total thermal	17848 7	Gcal/yr

Year	Annual Consumption		Annual Production	
		Thermal (Gcal)	Yarn (ton)	Cloth (lakh m)
Base year 1993-94	21 19	17848 7	3575	Nil
1992-93	8 57	24190	No prod	Nil
1991-92	18 72	10112 0	3240	Nil

	Yarn	Fabric
93-94	10 3 % inc in production	8 6 % inc in production

Unit : Hindon River Mills, Dasna, Ghaziabad

Process	Composite			
Commissioning Year	1972	Spindle capacity	40800 nos.	
Base Year	1993-94	Yarn Prod	3267	ton/yr
Turnover (Rs crores)	58 5	Cloth Prod	96 03	lakh m/yr
		Total electricity	26.67	GWh/yr
		Total thermal	63343 3	Gcal/yr

Year	Annual Consumption		Annual Production	
	Electrical (GWh)	Thermal (Gcal)	Yarn (ton)	Cloth (lakh m)
Base year 1993-94	26 67	63343.3	3267	96.03
1992-93	22.40	34538.5	2508	86 46
1991-92	22.76	32920 0	2574	95 70

	Yarn	Fabric	Power
91-92	2 6% reduc in production	10 6 % reduc in production	16 1 reduc in power consumption
92-93	30% inc. in production	12.6 % inc in production	19.1 increase in production

Unit : Siddhartha Super Spinning Mills Ltd, Solan, H.P.

Process	Spinning	Spindle capacity	24960 nos.
Commissioning Year	1991	Yarn Prod	4066 ton/yr
Base Year	1993-94	Cloth Prod.	Nil lakh m/yr
Turnover (Rs crores)	50	Total electricity	13 69 GWh/yr
		Total thermal	589.6 Gcal/yr

Year	Annual Consumption		Annual Production	
	Electrical (GWh)	Thermal (Gcal)	Yarn (ton)	Cloth (lakh m)
Base year 1993-94	13 69	589 6	4066	Nil
1992-93	13 99	269 6	4256	Nil
1991-92	13 01	358 5	4174	Nil

Avg count	26 87 (Synthetic)		
UKG (units per kg)	91-92	3 118	USS
	92-93	3 288	
	93-94	3 367	0 501
	92-93	Prod increased by 1 96% Power increased by 5 4%	
	93-94	Prod decreased by 4 5% Power decreased by 2 4%	
Employee per 1000 spindles	56		
Annual Turnover	-		

Unit : Rajasthan Textile Mills, Bhiwani Mandi, Rajasthan.

Process	Spinning	Spindle capacity	55336 nos	
Commissioning Year	1971	Yarn Prod	13455 3	ton/yr
Base Year	1994	Cloth Prod	Nil	lakh m/yr
Turnover (Rs crores)	N A	Total electricity	34.4	GWh/yr
		Total thermal	9996 5	Gcal/yr

Year	Annual Consumption		Annual Production	
	Electrical (GWh)	Thermal (Gcal)	Yarn (ton)	Cloth (lakh m)
Base year 1993-94	34.42	9996.5	13455 3	Nil
1992-93	34 04	8295 4	12289 9	Nil
1991-92	32 97	9022.5	12179 6	Nil

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